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Spruce Budworm in Eastern United States

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The spruce budworm (*Choristoneura fumiferana* (Clem.)) is one of the most destructive insects in the northern spruce-fir forests of the Eastern United States. It is native to the North American Continent. According to the incomplete historical records of the ravages of this insect, the first serious outbreak was reported in Maine about 1807. Another occurred there in 1878. The most serious outbreak began in Quebec about 1909, spread into Maine in 1910, and to Minnesota in 1913. This epidemic continued until 1926 and resulted in the loss of an estimated 47 million cords of balsam fir in the Eastern United States.

The latest outbreak began in Canada and reached epidemic proportions there in 1935. By 1944 the spruce budworm's presence in the United States was recorded when defoliation was observed in northern Maine and in northern New York. In 1954 infestations also became noticeable on the Superior National Forest in Minnesota. At present, over 1 million acres in Minnesota and nearly that acreage in Maine are affected.

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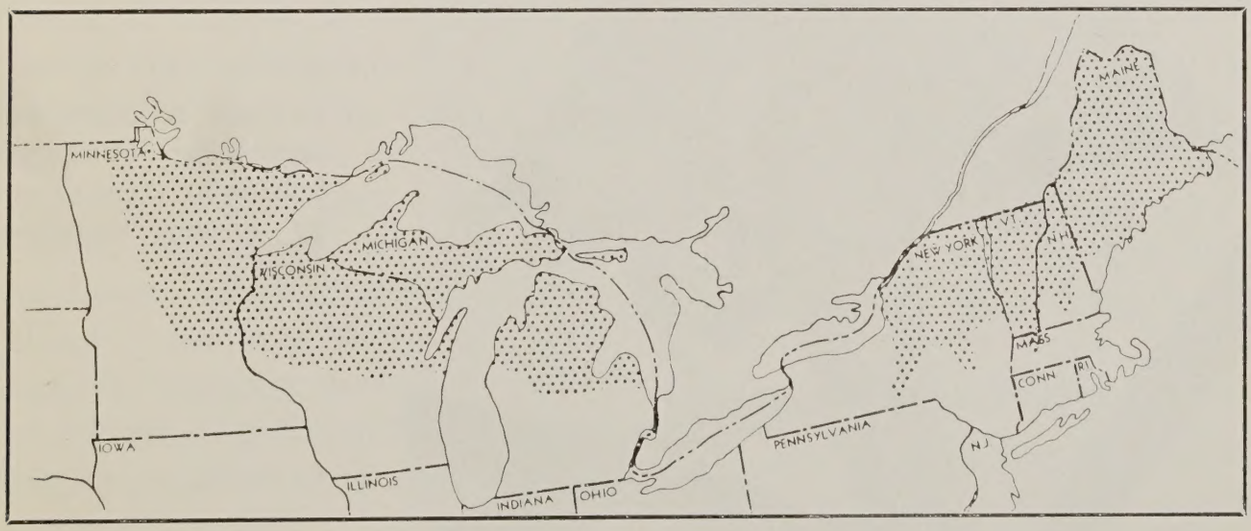

FIGURE 1.—Distribution of the spruce budworm in Eastern United States. The spruce budworm is also found throughout adjacent provinces of Canada. This distribution coincides with the range of balsam fir.

Host Trees

Balsam fir is the preferred host of the budworm in the Eastern United States. To a lesser degree white, red, and black spruce also are suitable host trees, and some feeding may occur on tamarack, pine, and occasionally hemlock. Spruce mixed with balsam fir is more likely to suffer budworm damage than is spruce in pure stands.

The range of the budworm in the Eastern United States is restricted to the Northern States, and it may be found wherever its preferred host species grow (fig. 1).

Damage and Evidence of Infestation

During the early larval stage the budworm is very small and difficult to detect. However, its habit of boring into and feeding on the expanding buds can cause severe damage to the buds (fig. 2), especially during heavy infestations. Later, needles severed at the base by the maturing larva are left hanging in the light, silken web spun during this period. These severed needles turn brown, giving the defoliated tree a scorched appearance. This condition is apparent from about mid-June until late August, these dates varying somewhat according to the weather.

During the early stages of an epidemic, defoliation is usually more noticeable in the top portion of the crown. After several years of heavy defoliation, the trees have a grayish color, and dead tops become conspicuous (fig. 3). Tree mortality often takes place after 3 or more years of heavy defoliation,

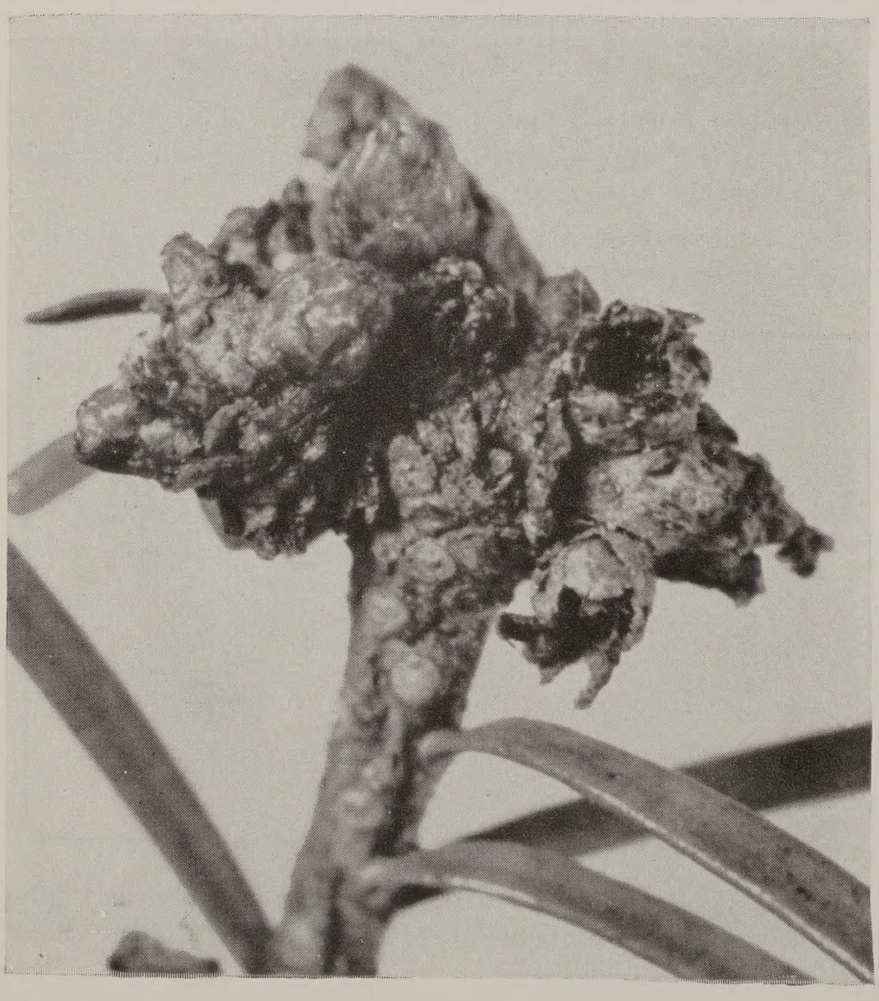

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FIGURE 2.—Terminal vegetative buds on balsam fir shoot mined by spruce budworm larvae.

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FIGURE 3.—Balsam fir severely defoliated by the spruce budworm.

depending on the general vigor of the trees.

Description

The adult moth has a wing expanse of three-quarters of an inch and in general is grayish with dark brown markings (fig. 4, *A*). Occasionally the moths are brown or reddish with gray markings. Males and females occur in equal numbers. The light-green eggs are about 1 mm. long by 0.8 mm. wide. Laid in elongate masses of 2 to 60 and averaging about 20, they overlap one another as do shingles on a roof (fig. 4, *B*).

The first-instar larva, about 2 mm. long, is yellowish green with a light- to medium-brown head. The second instar is yellow with a dark-brown or black head. During the succeeding four instars the body of the larva changes from a pale yellow to a dark brown with light-colored spots along the back. The mature larva is about 1 inch long, and the head is dark brown or shiny black (fig. 4, *C*). The pupa is light to reddish brown, marked with darker bands and spots (fig. 4, *D*).

Life History and Habits

In the Eastern United States there is one generation of spruce budworm a year. The female moth lays its eggs on the flat surface of a

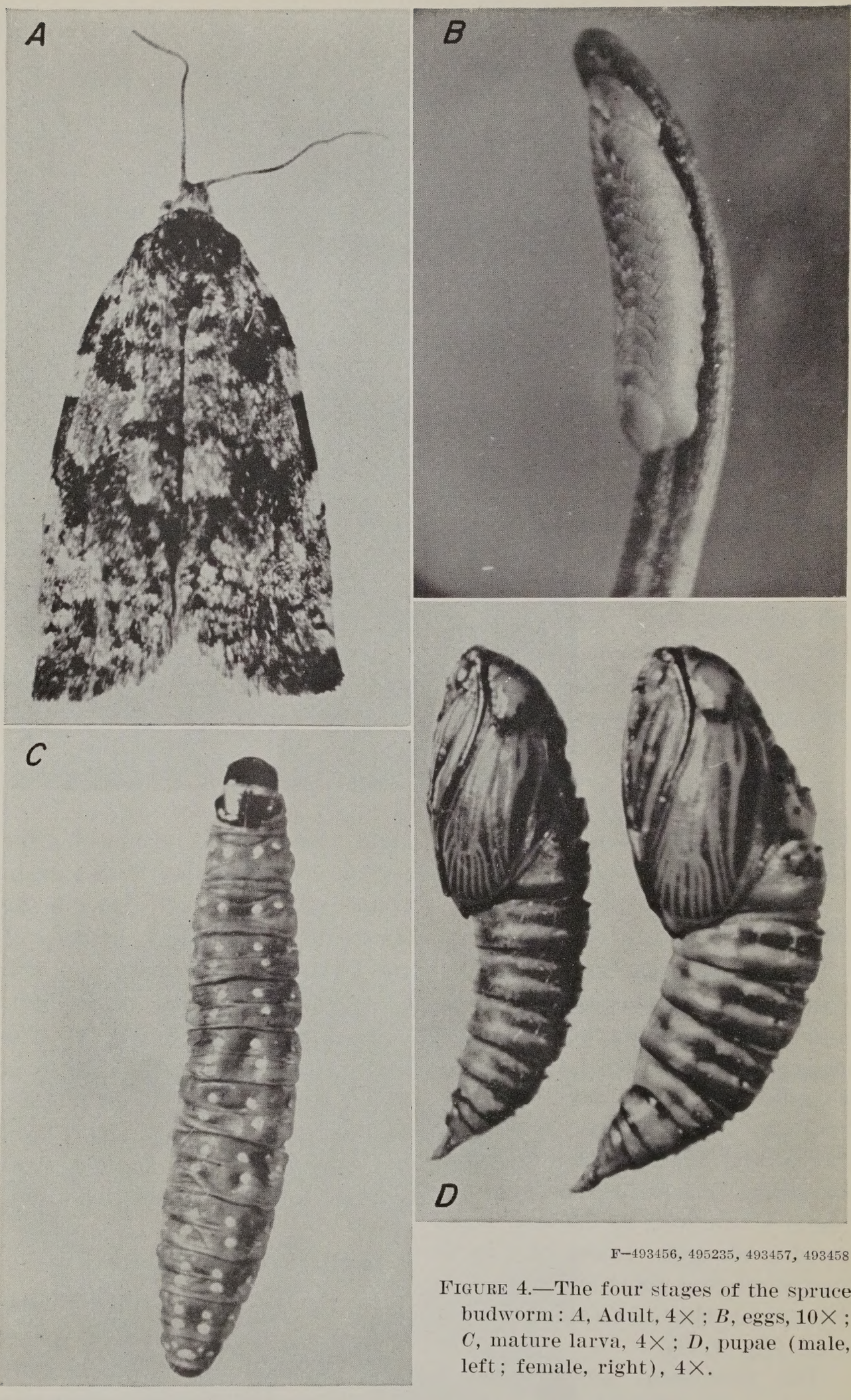

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FIGURE 4.—The four stages of the spruce budworm: *A*, Adult, 4×; *B*, eggs, 10×; *C*, mature larva, 4×; *D*, pupae (male, left; female, right), 4×.

balsam fir or spruce needle, generally on the twig tips within 3 inches of the buds or defoliated area. On host trees in the Northeastern States and Eastern Canada, the eggs may be more generally distributed on the foliage. The eggs hatch in about 2 weeks.

The newly hatched larva immediately seeks a suitable place to spin its overwintering hibernaculum. In doing so, it may spin down from a branch on a silken thread and be carried away by air currents. Larval dispersal at this stage is one means of spread within and beyond the infested stands. Old staminate flower bracts are generally preferred as overwintering sites (fig. 5), but bud scales and bark crevices are also used. Without feeding, the young larva transforms into the second larval instar within the hibernaculum and remains dormant over the winter.

In the spring after several days of warm weather but before the balsam fir buds begin to expand, the larva emerges from hibernation and starts feeding. Early feeding is first confined to the new buds of staminate flowers, if they are present; otherwise the larva mines into the older needles, generally the previous year's. The new flower buds provide a ready source of food prior to the softening of the vegetative buds. According to Jaynes and Spears (1949) the early larvae that feed on staminate flower buds grow much more rapidly and have a higher survival ratio than those that feed on the old needles.

After a short period the larva migrates to the end of a branch and bores into an expanding vegetative bud. Also during this period some larvae may spin down on silken threads and, as with the first-instar larvae, be dispersed by air currents.

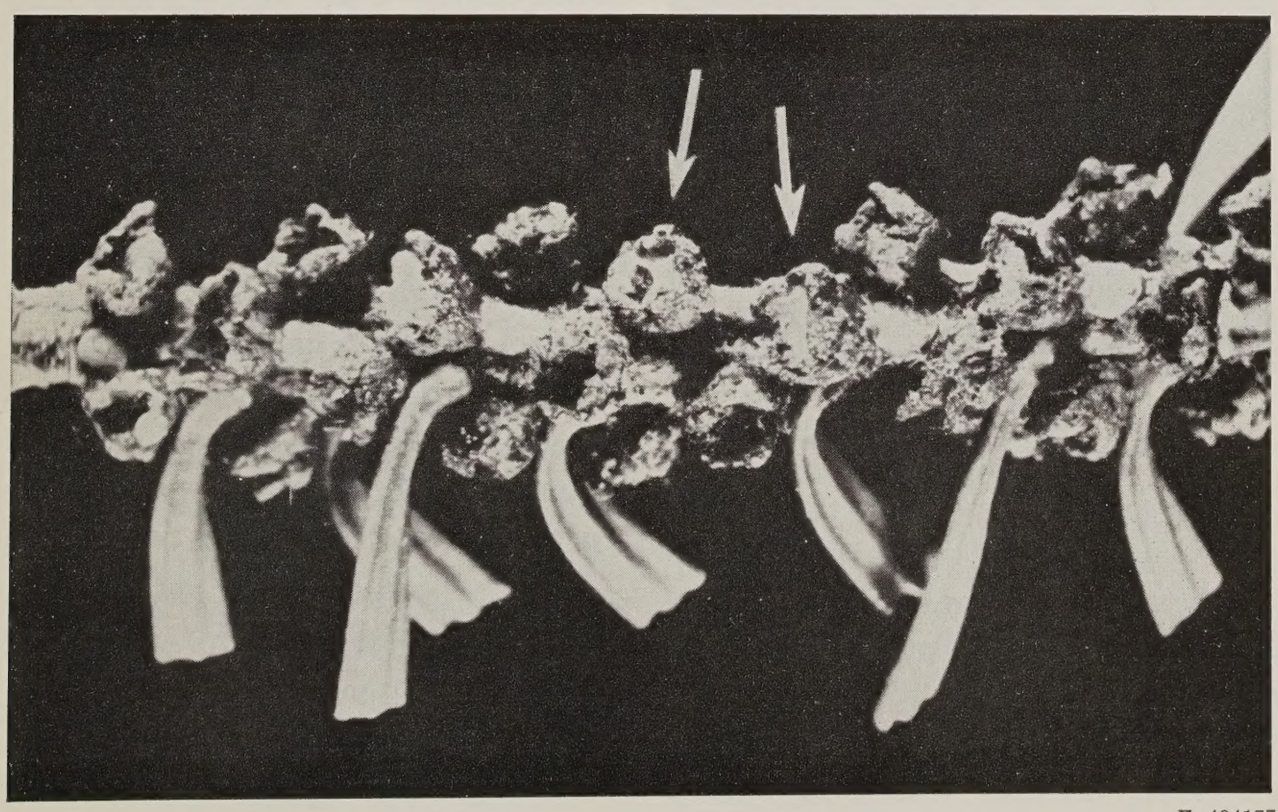

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FIGURE 5.—Staminate flower bracts on balsam fir showing webbing of hibernacula in cups.

Generally, however, the larvae feeding on staminate flower buds and flowers tend to stay in place, at least until the immediate food supply is depleted.

Later, the larva feeds on the new foliage of the developing shoots and when about half grown it begins tying the tips of two or more twigs together with silk, forming a small nest. The new foliage is preferred and is entirely destroyed before the old foliage is eaten. During the latter part of June or early July, depending on the weather, the larva completes development and stops feeding.

The larva then transforms to a pupa, generally within the last-formed webbing (fig. 6). Some pupae are found, however, at the axils of the twigs.

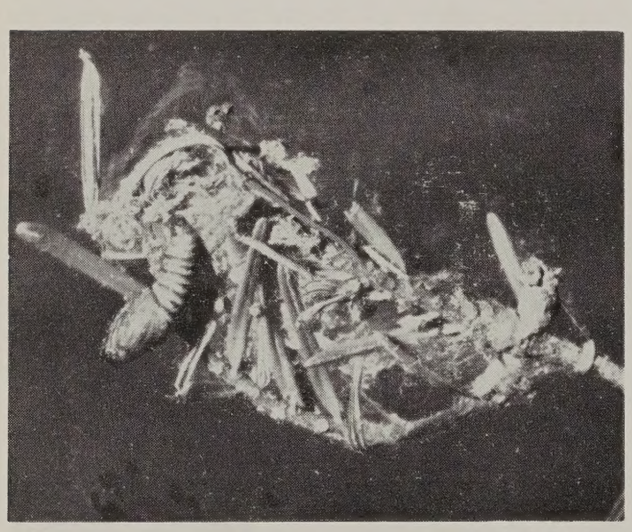

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FIGURE 6.—Defoliated shoot with spruce budworm pupa.

The moth emerges about 10 days later. Peak moth activity is from about 4 p.m. to 8 p.m. The moths may be carried up to 10 miles or more by normal winds, and they can be transported hundreds of miles by strong storm fronts.

Natural Control

Although the spruce budworm has a high reproductive capacity, natural factors such as adverse weather conditions, diseases, predators, and parasites play an important part in holding it in check during endemic periods. However, several successive years of favorable weather, plus forest conditions providing adequate food and suitable hibernation sites, may lead to an epidemic during which natural factors are unable to control the insect. Once spruce budworm outbreaks begin, they normally continue until the larvae have literally starved themselves by consuming all the available foliage.

Many species of parasites attack the spruce budworm during its various stages. Studies of heavy infestations in New York and Maine showed that a high parasitism of mature larvae by *Meteorus trachynotus* Vier. and *Lypha setifacies* (West.) is indicative of a declining budworm population.

Although these and many other species of parasites also attack the spruce budworm in the Lake States, to date no evidence of sustained control by them has been observed.

Recent developments in the use of diseases as biological control agents hold some promise for spruce budworm control. Graham (1948) reported a polyhedral virus disease of the budworm. Bird and Whalen later demonstrated the infectious nature of this disease and, with few exceptions, budworm larvae fed the polyhedra developed the disease within 72 hours. How-

ever, many of the larvae survived, indicating that this virus was not particularly deadly.

Thomson (1955) reported a microsporidian disease, *Perezia fumiferanae* Thom., that slowed down the rate of development during both the larval and pupal stages of the budworm. The length of life of infected adults was shortened. Females were affected more than males. To date neither of these diseases have proved successful in field trials.

In recent field tests, the pathogen *Bacillus thuringiensis* Berliner, has shown promise against the spruce budworm. However, these tests were only on a small scale and the practicality of large-scale use of the pathogen is yet to be demonstrated.

Indirect Control

Budworm outbreaks can develop and gain momentum in Northeastern United States only if there is a large proportion of mature and overmature balsam fir in the forest. Management practices that make conditions generally unfavorable to the budworm may reduce materially the future hazard of attack. These practices include utilizing balsam fir, regulating age classes to prevent the occurrence of large areas of overmature balsam fir, and favoring less susceptible species such as spruce.

In the Lake States young balsam fir stands (5 to 15 feet high) either next to mature balsam fir or white spruce stands, or containing scattered overstories of mature balsam fir or white spruce, often support heavy overwintering populations of the budworm. Vegetative buds, mined by spruce budworm larvae previously blown in or dropped from the overstory balsam fir, provide suitable hibernating sites for the next generation. The larvae are able to survive the winter and continue the infestation on these same trees the following year. One way to prevent infestations in these young stands would be to remove the overstory mature balsam fir and white spruce. Direct chemical control would be required for adjacent mature stands.

Direct Control

Chemical control is at present the only economical direct way to prevent widespread damage by heavy budworm populations. Aerial spraying with DDT, properly applied against fourth-instar through sixth-instar larvae, will give satisfactory control. The recommended spray mixture is 2 quarts of 25-percent DDT concentrate to which is added 2 quarts of No. 2 fuel oil. This should be applied at the rate of 1 gallon of mixture per acre. Special care should be taken in treating infested stands near large bodies of open water. The same mixture, applied at the rate of one-half gallon per acre, is recommended for these areas.

For ornamentals, a foliage spray of 6 level tablespoonfuls of 25-percent DDT emulsion concentrate or 10 level tablespoonfuls of 50-percent wettable powder in 5 gallons of water, applied with a knapsack sprayer, has proved satisfactory.

Spraying does not kill all of the larvae. Some are protected from the spray by the webbed foliage

within which they are feeding. Rather, spraying sharply decreases the larval populations and thereby reduces the amount of defoliation. Also, there is valid evidence that certain parasites survive in greater numbers than the budworm. Thus, spraying effectiveness is supplemented by increased effectiveness of these natural enemies.

CAUTION: DDT is poisonous. Store it in a plainly labeled container, away from all food. Follow directions and heed precautions given by the manufacturer. In forest spraying, avoid overdosing, especially in the vicinity of ponds and lakes and where flight lines cross streams.

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